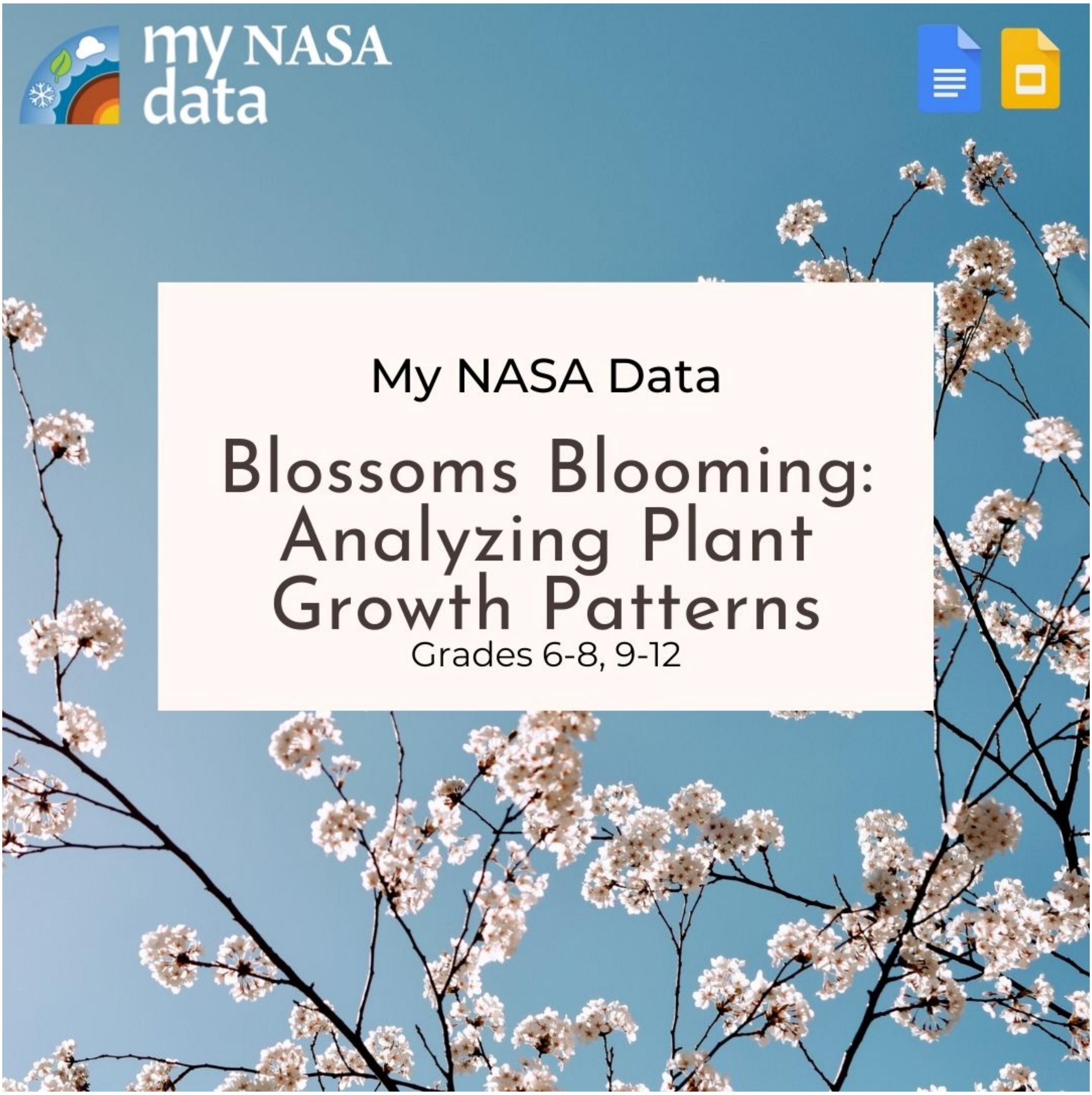
My NASA Data - Lesson Plans

Blossoms Blooming: Analyzing Plant Growth Patterns



Overview

Students analyze historic plant growth data (i.e., Peak Bloom dates) of Washington, D.C.'s famous cherry blossom trees, as well as atmospheric near surface temperatures as evidence for explaining the phenomena of earlier Peak Blooms in our nation's capital.

Learning Objectives

- Use evidence to create an explanation.
- Analyze Behavior Over Time graphs of plant phenology data for Washington, D.C.'s Cherry Trees from 1921- 2018.
- Compare Peak Bloom graphs to near-surface temperature data collected in the same region and time.
- Infer relationships between plant phenology and climate change supported by evidence and reasoning.

Why Does NASA Study This Phenomenon?

In eastern North America, the spring "green up" phenomena is one of the most dramatic changes Earth-observing satellites record, indicating the time when leaves appear and begin growing. For more than three decades, NASA satellites have collected seasonal vegetation data and scientists are discovering interesting and consequential findings; the Northern Hemisphere growing season has lengthened over the past 30 years or so as the climate has warmed. The spring green-up arrives a week earlier in many Northern Hemisphere locations; however, not all important seasonal events can be observed with satellites. The most important event in the life cycle of flowering plants—flowering itself—is too small-scale and variable for satellites to observe directly. Therefore, NASA scientists couple satellite data with the work from the broader research community featuring the Environmental Protection Agency and the National Park Service for validation purposes.

In this lesson, Blossoms Blooming: Analyzing Plant Growth Patterns, learners collect evidence from air temperatures and Peak Bloom data, to examine yearly variations in plant growth patterns from 1921 to 2018. Students connect Behavior Over Time (BOT) graphs with data sets and review other resources to evaluate this changing phenomenon.

Essential Questions

1. How does the Biosphere respond to changing atmospheric temperatures?
2. How has the Biosphere changed since the early 1900's through today?
3. What does plant phenology in the Washington D.C. area tell us about changing climates?
4. What effects do earlier phenology cycles in the calendar year have on other spheres in the Earth System?
5. How does NASA work with other organizations to help us better understand and interpret phenology data?

Materials Required

Per Student:

- Behavior Over Time: Analyzing Plant Growth Patterns Student Data Sheet

Per Group

- Students Datasets: Tidal Basin: Cherry Tree Peak Bloom Day of the Year, EPA (#1 to all, and divide the remaining ones among the groups)
- Student Graphs: Peak Bloom Day # Over Time
- Student Graph: Average Yearly Near-Surface Temperature (?)
- Station: Reagan National Airport (Alexandria, VA - Near Washington, D.C.) NOAA
- Optional: Data Literacy Cube to Facilitate Deeper Understanding

Technology Requirements

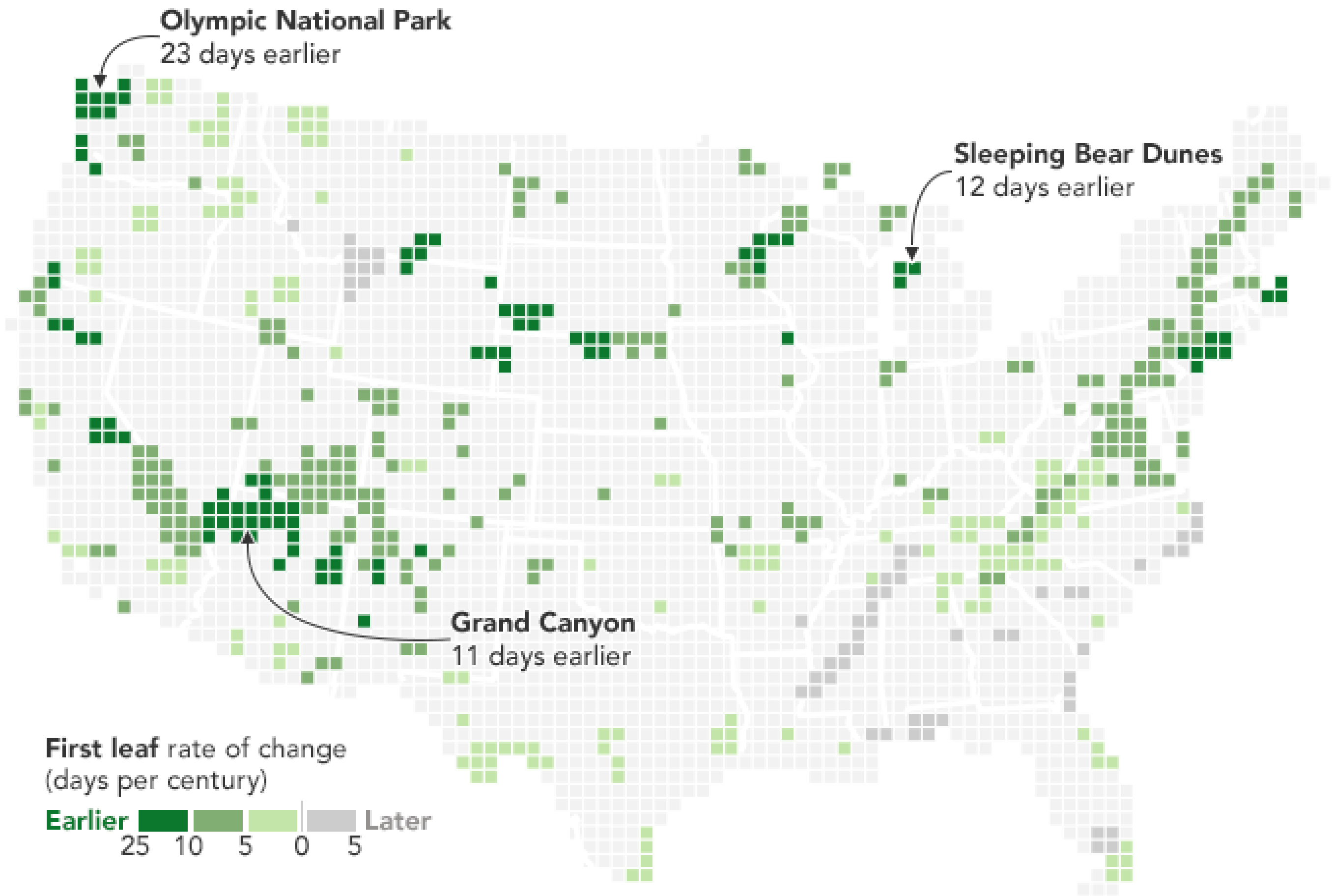
- Standalone Lesson (no technology required)
- Internet Required
- One-to-One (tablet, laptop, or CPU)
- One-to-a-Group

Teacher Background Information

Taken from: National Cherry Blossom Foundation

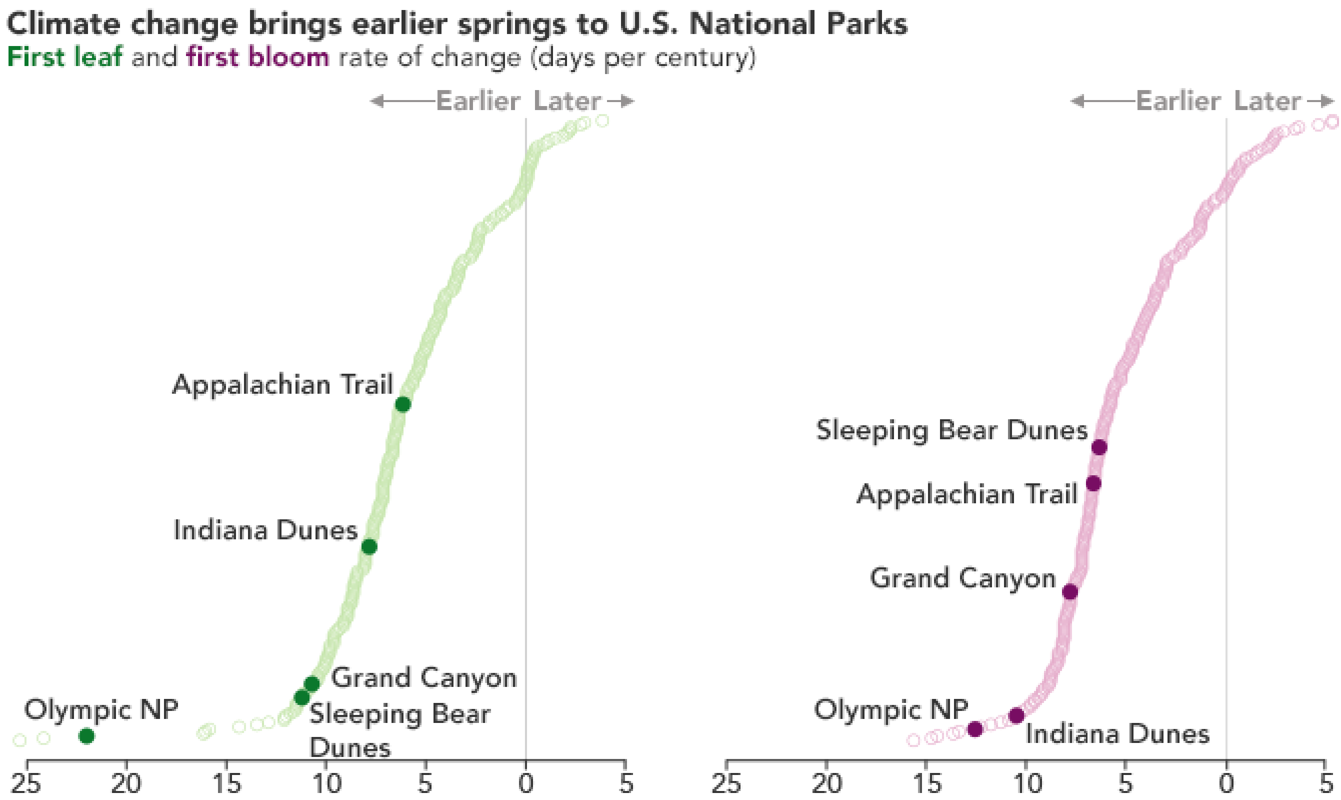
In the spring of 2018, the cherry trees around the Tidal Basin, southwest of the National Mall in Washington, D.C., reached Peak Bloom in early April 2018—timing that is in line with the 96-year average. After a warm February, cool March temperatures confounded models that had predicted the bloom to occur earlier than usual. That is not surprising, as temperature plays a crucial role in bloom timing. But over the longer term, climate change is causing spring to begin earlier and earlier across the United States.

Maps reveal just how much earlier spring is arriving in National Parks across the country. The data were published in 2016 by ecologists from the National Park Service, working in collaboration with colleagues at other agencies and institutions. The first map shows the rate of change (days per century since 1901) of “First Leaf”—the date at which leaves first appear from buds. The second map shows the same rate of change for “First Bloom,” the average date when blooms appear. Combined, the two indices provide a way for ecologists to identify how vegetation is responding to warming temperatures.


Olympic National Park
23 days earlier
Sleeping Bear Dunes
12 days earlier
Grand Canyon
11 days earlier
First leaf rate of change
(days per century)
Earlier
25 10 5 0 5
Later

Credit: NASA Earth Observatory, acquired 2016 download large image (372 KB, PNG, 7800x4700)

“Climate changes are affecting resources across the entire range of National Parks,” said John Gross a climate change ecologist with the National Park Service. “Earlier springs, as indicated by leaf and flowering dates, is one of the most obvious and easily understood effects of climate change.” Of the 276 parks in the study (including Alaska, not pictured), about three-quarters of them are experiencing earlier springs. More than half are experiencing “extreme” early springs; that is, recent springs are among the earliest ever observed—and in many cases are wholly unprecedented—compared to the past 112 years. The charts below show that indeed, the vast majority of parks are experiencing First Leaf and First Bloom earlier than usual. This means that most parks are already experiencing and responding to climate-driven changes.



Credit: NASA Earth Observatory

But as the maps also show, the magnitude of the change varies with location. Early blooming is evident in the swath of purple stretching from the south to the northeastern U.S. along the Appalachian Trail. Early leafing is quite evident in the southwestern part of the country, such as Grand Canyon National Park. Here, the long-term changes mean that spring is now arriving nearly two weeks earlier than it did in 1901. Still, other parks, such as Olympic National Park, are both blooming and leafing out earlier than normal. Conversely, some areas of the southeastern United States are not seeing much change at all; that region experienced less warming in the second half of the 20th Century.

Earlier springs have implications for how national parks are managed. The Cherry Blossom Festival in Washington, D.C., for example, has been lengthened to a multi-week event, making it more likely that the timing of the festival and Peak Bloom overlap. As the timing of spring has advanced, parks also have had to adjust the timing of management actions, which include hiring seasonal staff, opening park facilities, and initiating control of pests and invasive plants. According to Gross, park visitors are highly attuned to the beauty of the spring—from the emergence of buds to colorful flowers that emerge—and can observe for themselves how warming is changing the seasonality of parks. An earlier spring can affect the relationships between plants and pollinators, the wildlife that migrate in response to the greening of the plants they eat, and the return of birds that rely on the emergence of insects to feed their young.

“Changes in leaf and flowering dates have broad ramifications for nature,” Gross said. “Pollinators, migratory birds, hibernating species, elk, and caribou all rely on food sources that need to be available at the right time. Warming climates have disrupted these patterns, causing hardships for the animals and people that rely on them.”

NASA Earth Observatory images by Joshua Stevens, using data courtesy of Monahan, William B., et al. (2016).
Story by Kathryn Hansen.

References and Related Reading

- EPA Climate Change Indicators (2016, April) Community Connection: Cherry Blossom Bloom Dates in Washington, D.C. Accessed April 5, 2018.
- Monahan, W.B. et al. (2016) Climate change is advancing spring onset across the U.S. national park system.Ecosphere, 7 (10).
- NASA Earth Observatory (2016, May 12) Natural Beauty at Risk: Preparing for Climate Change in National Parks.
- National Cherry Blossom Festival (2018, April) Bloom Watch 2018. Accessed April 5, 2018.
- The Washington Post (2018, March 20) Spring is springing earlier and earlier. Accessed April 5, 2018.
- Chung U, Mack L, Yun JI, Kim S-H (2011) Predicting the Timing of Cherry Blossoms in Washington, D.C. and Mid-Atlantic States in Response to Climate Change PLoS ONE 6(11): e27439.

Perhaps you are not interested in integrating the First Bloom of cherry blossoms into your instruction? Do not worry. Explore the phenology of native plants endemic to your area by using Budburst.

Budburst offers citizen science opportunities for students and teachers to better understand plant phenology in relation to environmental change for a wide variety of plants and locations. Budburst contains many resources to integrate phenology observations including the ability to create student accounts and build a research site listing specific plants. Or, if you prefer to download and use phenological data today, you can query the database by plant, location, or date.

Prerequisites Student Knowledge

- Line Graphs
- Life cycle of plants
- Simple plant/environment interdependencies

Student Misconception

- Scientists have already studied all the Earth’s systems so there will not be any new discoveries.

- Earth events taking place within the global environment are not interconnected,
- such as El Nino is not important to people living in the Midwest.
- The atmosphere, hydrosphere, lithosphere, and biosphere do not cause changes in
- one another; these systems operate independently on Earth.
- Increases in global temperatures in the atmosphere and the consequent warming of the oceans will only create a problem for people living along the coast.
- Earth has always been pretty much the way it is now.
- Life on Earth can not modify or cause changes in the Earth's systems.
- Earth is too big for us to change, thus the impact of our activities is inconsequential.

~ Credit: Center for School Reform at TERC's MSPnet

Procedure

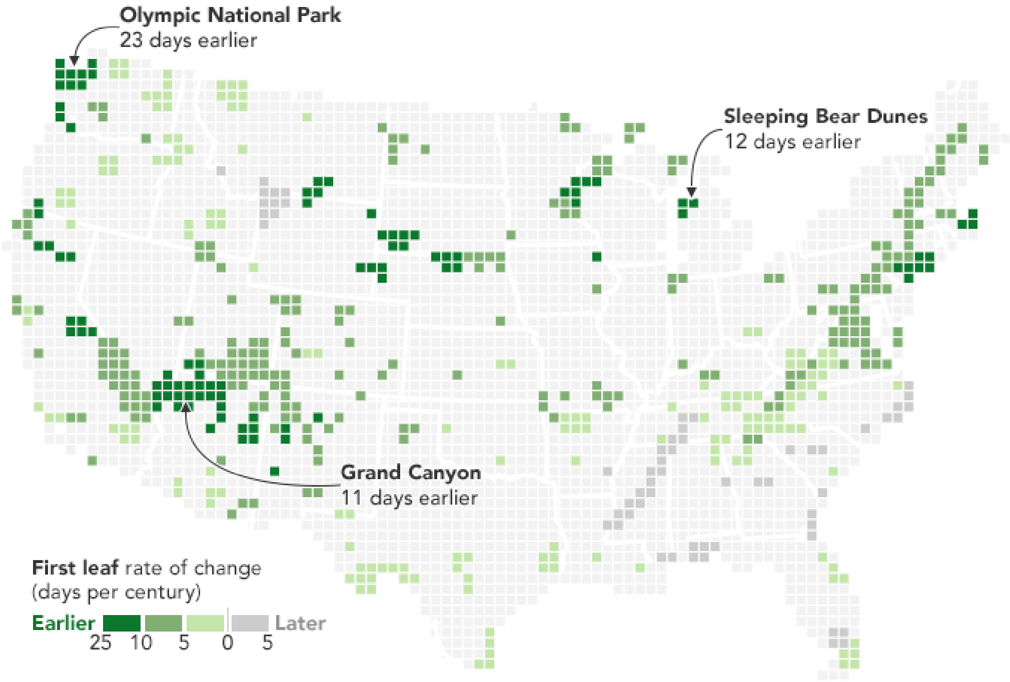
Part A: Engaging Prior Knowledge of Washington D.C.'s Cherry Blossoms

> BREAKING NEWS - Cherry blossom peak bloom is forecast for March 14-17. It could be the earliest date on record. #CherryBlossomDC https://twitter.com/hashtag/BloomWatch?src=hash">#BloomWatch pic.twitter.com/BypQVtUHbH
>
> — National Mall NPS (@NationalMallNPS) March 1, 2017

Credit: Twitter

1. To engage prior knowledge, project the following Twitter post and elicit student discussion with the following questions:
    1. Who sent the tweet?
    2. When?
    3. Where is the setting?
    4. What is the nature of the post?
    5. Why may this information be important?
    6. Who would likely care about this?
2. Introduce Cherry Blossoms and brief phenology of plants. Explain to students that they will be analyzing the Peak Bloom of Washington, D.C. cherry blossoms for change in Day of the Year. (See Day of the Year Charts to help students understand how time is measured.)
3. Review and discuss the following with students:

    1. Define *plant phenology*. Explain two factors that affect a plant's life cycle.
    2. When do the Yoshino cherry trees normally bloom or hit Peak Bloom in Washington, D.C.?
    3. What affects the scientists' prediction of Peak Bloom?
    4. Observe and compare the two maps of the contiguous United States for First Leaf and First Bloom in National Parks across the country. What is each image showing and how does it relate to phenology? What do the colors represent? When was the data



Credit: NASA Earth Observatory, acquired 2016 download large image (374 KB, PNG,

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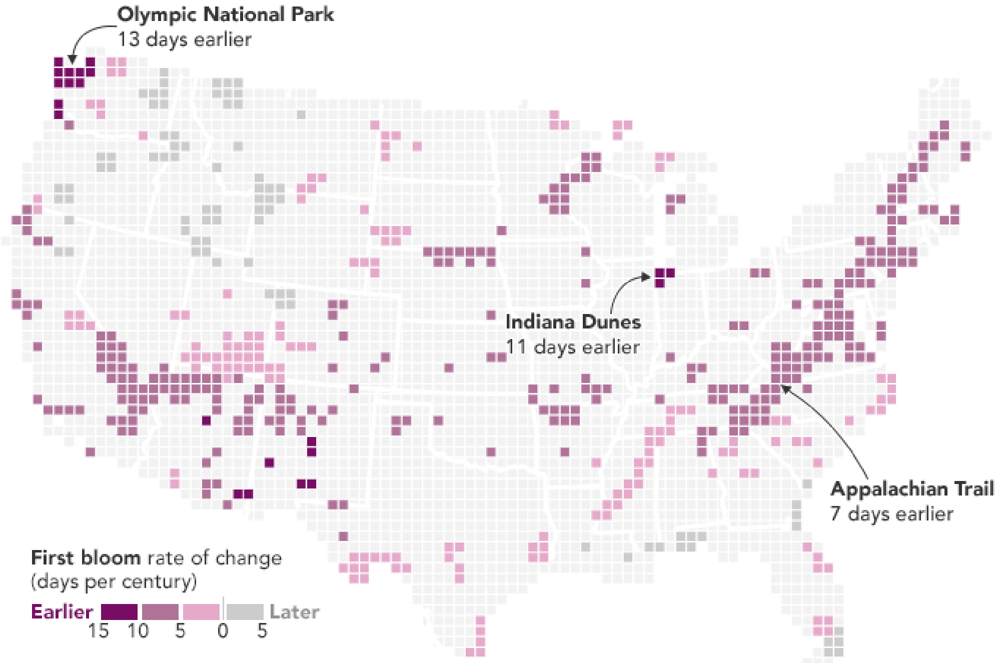
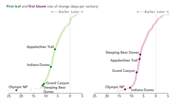


Credit: NASA Earth Observatory, acquired 2016 [download](#) large image (372 KB, PNG, 7800x4700)

5. Look at the two graphs that refer to climate change bringing earlier springs in U.S National Parks. What do the graphs show us about most parks? Is First Leaf and First Bloom the same in all National Parks. Google the listed National Parks. Are they the same latitude? How are the same or different? Who should care about the differences? How might the fluctuation affect food sources or migration? *The charts*



Credit: NASA Earth Observatory

6. Introduce the variable of Average Near-Surface Temperature. Explain to students that meteorological data was collected since the 1940's by the government near the tidal basin and these data may give us clues about the changes in cherry blossoms. Ask 7800x4700) students the following questions:
   - How does the temperature change from month to month?
   - What effect does this have on the life cycle of plants?
   - How have temperatures changed in the Earth System over the last couple of decades?
   - What role might this play on the phenology of plants?

4. Distribute the Student Data Sheet and datasets and graphs to each student and review.
5. Have students write a claim statement about the relationship of Peak Bloom Dates and Near Surface Air Temperatures and how they have changed over decades. e.g., My claim is that _____…; I believe _____ ; I think _____ will happen.
6. As a whole class, students will record and analyze your observations for Dataset 1 (Peak Bloom- Day of Year for Washington D.C.'s cherry trees. Discuss students' observations, and any patterns/trends.

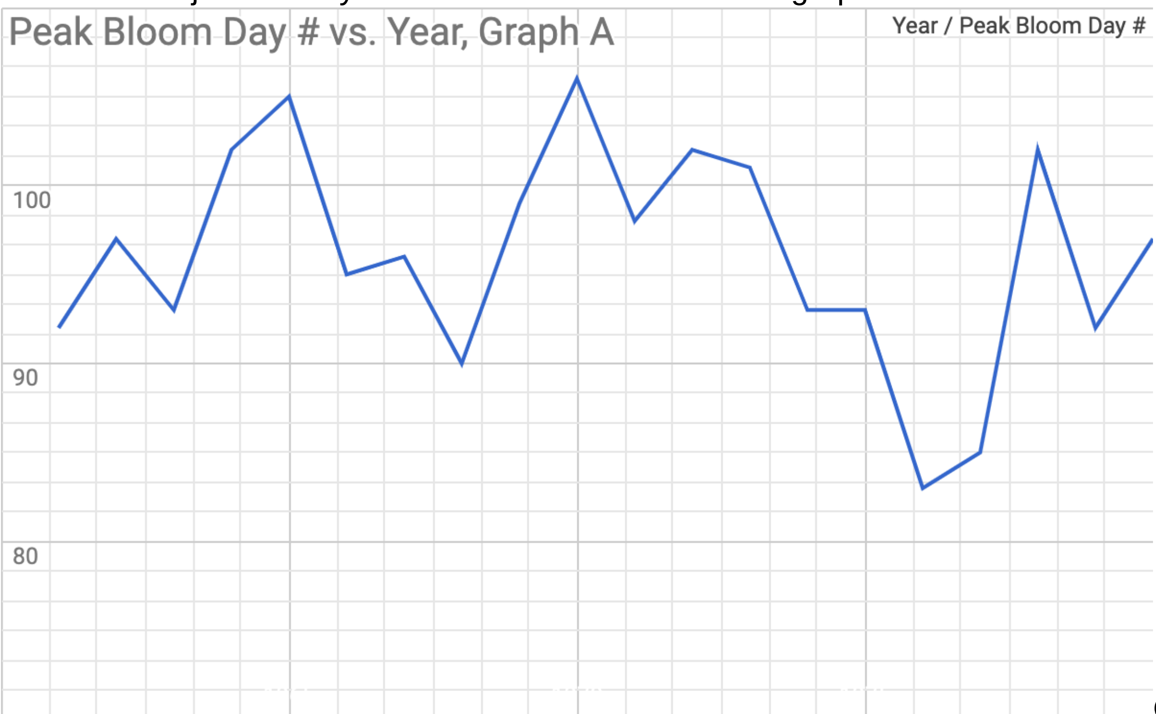
below show First Leaf (left) and First Bloom (right) in U.S. National Parks.

Students Datasets:
Tidal Basin: Cherry Tree Peak Bloom Day of the Year, EPA

Dataset 1		Dataset 2		Dataset 3		Dataset 4		Dataset 5	
Year	Peak Bloom Day #	Year	Peak Bloom Day #	Year	Peak Bloom Day #	Year	Peak Bloom Day #	Year	Peak Bloom Day #
1921	79	1941	102	1961	92	1981	93	2001	97
1922	97	1942	95	1962	97	1982	97	2002	92
1923	99	1943	94	1963	93	1983	97	2003	92
1924	104	1944	100	1964	102	1984	94	2004	91
1925	86	1945	79	1965	105	1985	97	2005	99
1926	101	1946	82	1966	95	1986	92	2006	89
1927	79	1947	102	1967	96	1987	87	2007	91
1928	99	1948	88	1968	90	1988	91	2008	89
1929	90	1949	88	1969	99	1989	88	2009	91
1930	91	1950	99	1970	106	1990	74	2010	90
1931	101	1951	96	1971	98	1991	88	2011	88
1932	106	1952	100	1972	102	1992	96	2012	80
1933	99	1953	86	1973	101	1993	101	2013	99
1934	105	1954	96	1974	93	1994	95	2014	100
1935	91	1955	92	1975	93	1995	92	2015	100
1936	98	1956	97	1976	83	1996	95	2016	85
1937	104	1957	98	1977	85	1997	85	2017	115
1938	84	1958	108	1978	102	1998	86	2018	95
1939	89	1959	96	1979	92	1999	95		
1940	104	1960	105	1980	97	2000	77		

Credit: NASA/My NASA Data

7. Next, draw students' attention to the fact that the X Axes on each graph are unlabeled. It is the students' job to analyze their dataset and select the graph that matches the set.



Credit: NASA/My NASA Data

8.

Observed Years	**Observed Evidence**	
	Peak Bloom (Day of the Year)	**Average Near Surface Air Temp (°C)**
Dataset 1: 1921-1940		*(unavailable for this timeframe)*
Fill in the Blanks: **Dataset #____________:** **Observation Dates:** ________________ - ________________		

Credit: NASA/My NASA Data

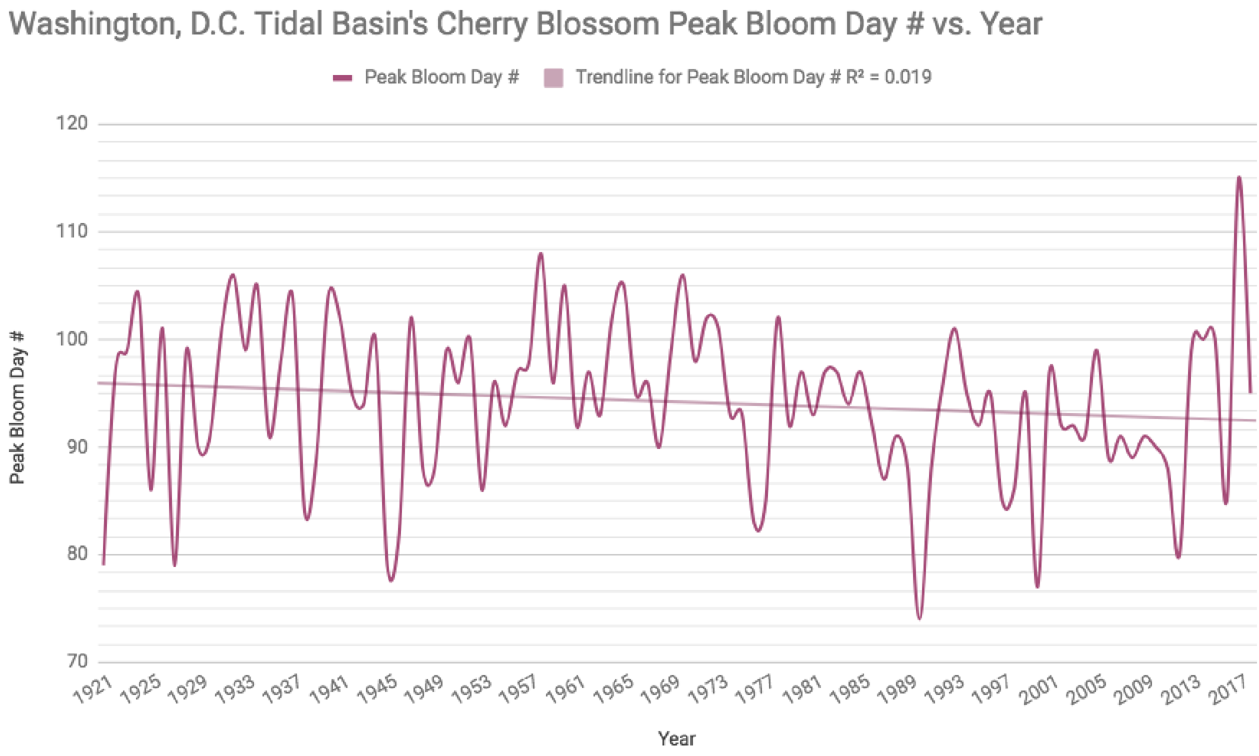
Then, divide students into small groups and assign the remaining datasets to be analyzed, one per group (i.e., Dataset 2: 1941-1960, Dataset 3: 1961-1980, Dataset 4: 1981-2000, Dataset 5: 2001-2018). Students will document their dataset number and observation dates in the data sheet and repeat Step 7.

9. Students will analyze their graphs and write their observations in the Student Data sheet. Observed Evidence in the Left-hand column, Peak Bloom (Day of the Year).

10. Review the correct order of the graphs with the students using the Teacher Graphs: Peak Bloom Day # Over Time (Labels added and in order).

    - As a class, compare the groups' datasets and graphs. Direct students observations by asking:
    - What do you observe? Is there a trend? Is the trend positive, negative, cyclical, etc.
    - What additional evidence did the other groups' data/graphs provide? What contributions does your data and graph provide to the other groups?
    - If you were presenting to scientists, what evidence would you use to defend your statement about this trend?

11. Display the summary graph that consists of the individual graphs. Describe the trend over time showing that the Peak Bloom dates occur earlier in the calendar year. One can infer that if this trend continues that spring will appear earlier than in years past.



Credit: NASA/My NASA Data

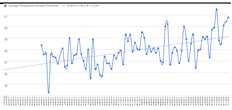
Part B: Climate Change and Cherry Blossoms in Washington, D.C.

1. Before showing the video, present the following questions found in #3 on the Student Data Sheet for students to find answers to during the video: (NOTE: Students should document their findings and report out to the class.)
    1. How has the life cycle of cherry blossoms changed? What changes have been observed?
    2. What explanations can you suggest for these patterns? What variable/s contribute to the change?
    3. Analyze and explain the relationship between key variables: air temperature and cherry blossom Peak Bloom dates in the spring:

        1. Are the relationships directly proportional (as one value increases, another value increases at the same rate)?
        2. Are the relationships inversely proportional (when one amount decreases at the same rate that the other increases)?
2. Show students the National Park Service Video (4min)

3. After the video, ask students to compare any new evidence revealed in the video to their predictions in Column A. Prediction on their Data sheet.
4. Students should share their findings with the class.

Part C. Observing More Data -- Comparing Temperature & Peak Bloom



Credit: NASA/My NASA Data

2. Students will analyze the part of their graph that represents the span of time 

Credit: NASA/My NASA Data they previously reviewed for Peak Bloom.
3. Students write their observations in Observed Evidence on the Student Data sheet in the right-hand column.
4. Students should report their findings to the class. Note: Students should collect information from peers' reports to include in their data tables. All cells in the table should be completed by the end of the lesson.
1. Now, distribute the Student Graph: Near-Surface Temperature to each group.
5. Teacher Tip: See the [Data Literacy Cubes - Graph Cube] to engage students in making deeper meaning of graphed data through hands-on activity.

Part D: Interpreting the Data

1. Students revisit their claim and predictions as compared to their evidence by completing Step 5 on their data sheet.
2. Students describe any ideas that the evidence has sparked and any scientific principles that affect their findings: Connection of seasonal effects on temperature, phenology of plants and animals, climate change, etc.

Part E: Thinking Big Picture

Encourage students to think beyond the obvious as they begin to connect the Biosphere to the other parts of the Earth System. Students complete questions 6-8.

Extensions

How to Report on Cherry Blossoms

Reporting on your local cherry tree as it blossoms is easy! Note that with cherry trees, flowering occurs before leafing - this is not the case with all deciduous trees.

- Identify your Cherry Tree - there are eight cherry species on the Budburst Plant List . Even if your cherry tree is not on our list, you can still submit a report!
- Log into your Budburst Account - submit your One-time or Life-cycle Report using your handheld device or record your observations on a field report form (downloadable from the plant webpage) and post your findings later.
- Track your data - check your cherry blossom data from previous years in your Budburst Account, or view data from other observers using the Data menu. Is this year's blossoming earlier or later than previous years?

We invite you to track your tree over the entire growing season. Create a Life-cycle Report to follow your tree through multiple phenophase events: Bud burst, first leaf, all leaves unfolded, first flower, full flower, first ripe fruit, full fruiting, 50% color and 50% leaf fall.

All observations - whether Life-cycle or One-time - are helpful in understanding how plants respond to changes in climate and atmosphere over time.

Credit: Project Budburst's Cherry Blossom Blitz

To further your classroom's inquiry with the phenological studies of cherry blossoms beyond Washington D.C., visit the Project Budburst's Cherry Blossom Blitz courtesy of Chicago Botanic Gardens. Here, you can observe a local cherry tree with your students from February 15th through April 30th and report and report how the tree is changing. The Cherry Blossom Blitz is a continental-scale campaign targeted to the collection of cherry blossom data by the public for research.